Supporting Information

Green synthesis of carbon quantum dots from lemon peel waste: Applications in sensing and photocatalysis

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Characterization techniques

Fourier transform infrared (FTIR) spectra of the wsCQDs were analyzed with Bruker Fourier transform infrared spectrometer (Vector 22 model) using KBr pellets. Zeta potential measurement was done in aqueous solution with Malvern Zetasizer Nano ZS 90 to measure the surface charge on wsCQDs. Thermogravimetric analysis (TGA) was carried out by using a C. I. electronics analyzer on a SDTQ600, TA instruments, (waters LLC, 159 Lukens Drive, New Castle DE 19720) in nitrogen atmosphere at heating rate of 10 ˚C-min^{-1} and amount of wsCQDs loading over TiO_2 nanofibers was found using TGA. The surface morphology of the wsCQDs and TiO_2-wsCQDs composites was done by using field-emission scanning electron microscopy (FESEM) SUPRA 40VP, Carl Zeiss (NTS GmbH, Oberkochen, Germany) microscope operated at 10 kV in high vacuum mode and by using transmission electron microscopy (TEM) (Tecnai 20 G2 STWIN model) at an accelerating voltage of 200 kV. Samples for TEM characterization were prepared by drop casting 5μL aqueous solution onto a carbon coated copper grid (mesh size 400) and vacuum dried. UV−visible absorption spectra were performed by Double beam UV-visible spectrometer (Varian Cary 100, Germany). Perkin Elmer LS 55 spectrophotometer was employed to record photoluminescence (PL) behavior. The PL spectra were recorded at room temperature in aqueous solutions. X-ray photoelectron spectroscopic (XPS) measurements were carried out with PHI 5000 Versa Probe II, FEI Inc. spectrometer. The XPS binding energy values for wsCQDs were charge-corrected placing the main C 1s peak at 284.6 eV. XRD pattern of TiO_2 nanofibers and TiO_2-wsCQDs composite were recorded using PANanalytical, Netherlands with X-ray source of wavelength (1.5406 Å).

Quantum yield determination of wsCQDs

The relative quantum yield of synthesized wsCQDs was measured with reference to quinine sulphate as reported earlier[1] by using following equation:

$$Q_x = Q_{ST}(I_x/I_{ST})(A_{ST}/A_x)$$

where Q is the quantum yield of wsCQDs, I is the measured intensity of fluorescence emissions, and A is the absorbance. ST represents to the standard and x represents the sample. The comparative emission intensity of wsCQDs after one year of storage (red line) and fresh solution (black line) at 360 nm excitation wavelength is shown in Figure S1.

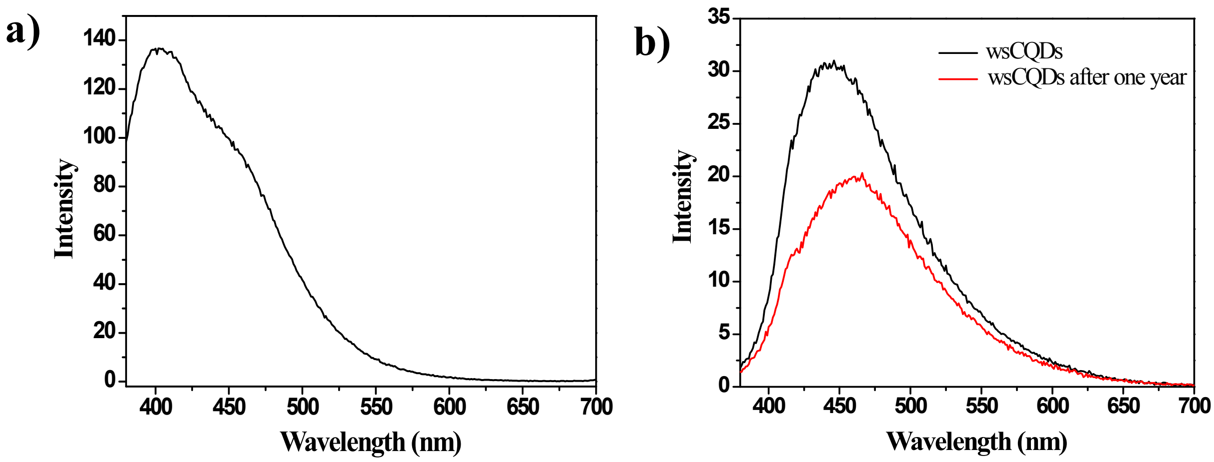

Fig. S1 (a) PL emission spectra of reference quinine sulfate; (b) Comparative PL emission of wsCQDs fresh (black line) and after one year of storage (red line) at 360 nm excitation wavelength.

Table S1. Comparison of quantum yield of CQDs derived from lemon peel waste with the reported CQDs

Carbon Source	Synthesis method	Application	QY(%)	Reference
Pomelo peel	Hydrothermal	Hg^{2+} sensing	6.9	2
Aloe	Hydrothermal	Tartrazine sensing	10.4	3
Soy milk	Hydrothermal	Electrocatalyst for oxygen reduction	2.6	4
Honey	Hydrothermal	Fe^{3+} detection	19.8	5
Graphite rod	Electrochemical exfoliation	Photocatalytic activity	16.5	6
Eggshell membrane	Microwave assisted	Glutathione sensing	14	7
Willow bark	Hydrothermal	Glucose detection	6	8
Flour	Microwave assisted	Hg^{2+} detection	5.4	9
Graphite powder	Laser ablation	-----	4.0-10	10
Carbon soot	Arc discharge	-----	1.6	11
Chicken eggs	Plasma induced	Fluorescent carbon inks for printing	6-8	12
Lemon peel	Hydrothermal	Cr^{6+} sensing and photocatalytic activity	~14	This work

Table S2. Performance comparison among various fluorescence based sensors toward Cr^{6+} detection

Fluorescent sensor	Response time	Detection limit	Reference
Rhodamine B hydrazide	60 min	5.5×10^{-9} mol L^{-1}	13
CdTe quantum dots	40 min	0.008 μg mL^{-1}	14
N-Doped graphene quantum dots	NA	40 nM	15
Hydrophilic ionic chemosensor	30 s	9.2×10^{-8} M	16
Glutathione-stabilized gold nanoclusters	30 min	2.5 μg L^{-1}	17
N, S-Doped carbon dots	NA	20 nM	18
Perylene nanoparticles	NA	0.008 μg mL^{-1}	19
wsCQDs	1 min	73 nM	This work

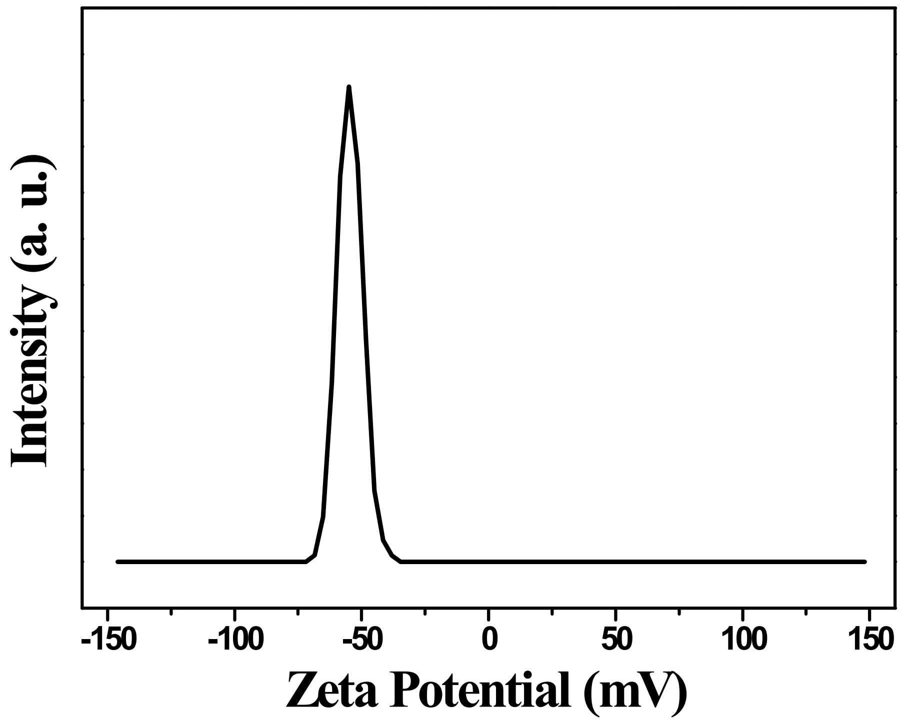

Fig. S2 Zeta potential curve for aqueous solution of wsCQDs at 25 °C.

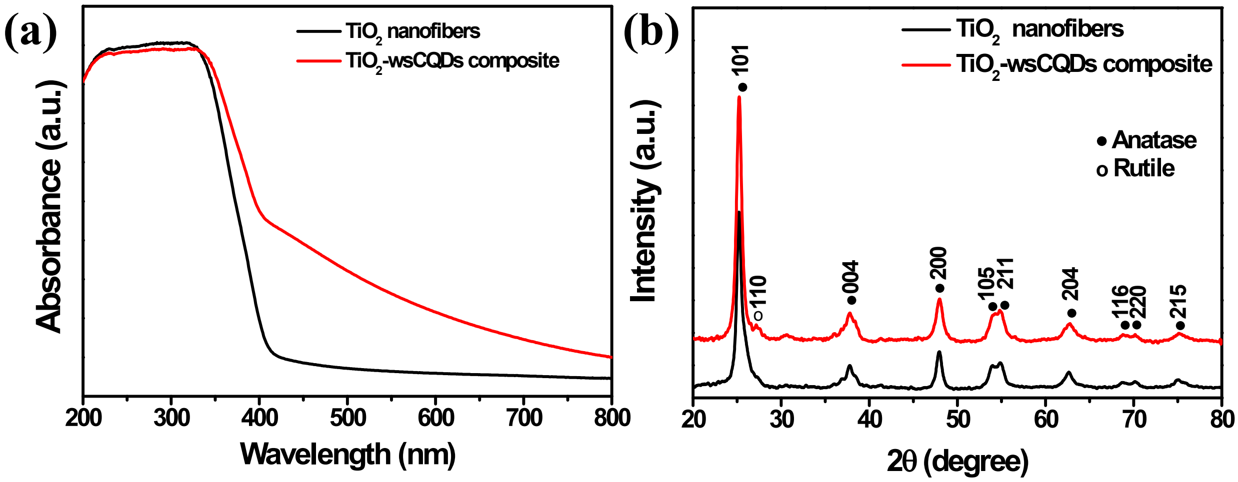

Fig. S3 **(a)** UV-vis spectra TiO_2 nanofibers and TiO_2-wsCQDs composite; **(b)** XRD spectra of TiO_2 nanofibers and TiO_2-wsCQDs composite.

Photocatalytic reaction steps:

$TiO_2 + h\nu \rightarrow TiO_2\,(e_{CB}^- + h_{VB}^+)$

$TiO_2(e_{CB}^-) \rightarrow$ wsQCDs (e_{CB}^-)

$h_{VB}^+ + H_2O \rightarrow OH^{\bullet} + H^+$

$h_{VB}^+ + OH^- \rightarrow OH^{\bullet}$

$e_{CB}^- + O_2 \rightarrow O_2^-$

$e_{CB}^- + O_2^- + 2\,H^+ \rightarrow H_2O_2$

$e_{CB}^- + H_2O_2 \rightarrow OH^{\bullet} + OH^-$

MB + reaction intermediates$\rightarrow$ degraded product

Table S3. Photocatalytic performance comparison with other carbon dot heterostructures

Material	Morphology	Pollutant	% Increase in photocatalytic activity	Reference
TiO_2	Particle	RhB	24	20
ZnO foam	Nanoparticle	RhB	~8	21
TiO_2	Nanobelt	MO	~23	22
ZnO	Chain like	Naphthol blue-black	15.7	23
Graphitic carbon nitride	Chiffon-like ripples and wrinkles	RhB	~56	24
ZnO	Particle	RhB	50	25
TiO_2	Nanofiber	MB	31	This work

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